WASHINGTON
SCIENCE TRENDS

HIGHLIGHTS

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* SPECIAL REPORT ---- GAS CENTRIFUGE PROGRAM

(Editors Note: Due to the unusual interest in the Gas Centrifuge program of the Atomic Energy Commission this Special Report is being mailed to subscribers in advance of our regular publication date.)

Private Industry to Participate

The Atomic Energy Commission proposed this week to permit private industry to work in classified areas of the gas centrifuge field, including those which may lead to less expensive nuclear power and nuclear weapons. In addition to AEC-sponsored programs, industry would employ its own funds for this effort.

"Not Simple Nor Cheap"

Here is what AEC Chairman John McCone has to say on the Status and Prospects of Gas Centrifuge Technology:

"After careful study and discussions with many qualified scientists about the gas centrifuge process, it is my conclusion that practical use of this method by any nation for producing weapons material is several years away. There is an enormous amount of development work still to be done. We foresee that the gas centrifuge ultimately can be used to separate uranium-235 from uranium-238 to produce weapons-grade materials. But this cannot be done satisfactorily with present technology. We do not think that the problems that remain are insoluble, but they certainly will take time to solve.

"This process will not be simple nor cheap. Apparently, as we see the trend of future development it will take thousands of gas centrifuge machines to produce material for weapons. With auxiliaries, these machines might cost several thousand dollars each.

"A country that is advanced scientifically and industrially would require a number of years -- perhaps as many as eight -- to perfect the gas centrifuge to the point where it could produce enough material for a nuclear weapon. Less industrialized countries will take much longer; the period of time depends upon how much outside assistance they receive.

"We do not minimize the potential importance of this process, however. Although the gas centrifuge does not pose an immediate prospect for production of weapons material, there is no doubt in my mind it will introduce an additional complicating factor in the problems of nuclear arms among nations and our quest for controlled disarmament. If successfully developed, a production plant using the gas centrifuge method could be simply housed. Its power requirements would be relatively small, and there would be no effects of the operation which would easily disclose the plant. Therefore, a clandestine plant would not be as easy to detect as a gaseous diffusion plant."

What is the Gas Centrifuge?

The gas centrifuge is a machine which is being developed for the separation of heavy isotopes which can be handled in gaseous form. An example is the separation of uranium-235 from uranium-238 in a system employing gaseous uranium hexafluoride. Because of its potential use in the production of weapons material, technology on the gas centrifuge is classified.

What is the AEC's Planned Program?

The Commission's planned program includes these three major areas:

✓ Continuation of basic research, which has been underway at the University of Virginia.

✓ Experimental operation of small groups of machines incorporating presently available technology. This work is being done for the Commission under contract by Union Carbide Nuclear Corporation at Oak Ridge, Tennessee.

✓ A new program under which private companies will be invited to submit proposals to perform development work under contract for AEC. This work would be for the purpose of developing advanced models of the gas centrifuge.

The AEC states that industry believes there is substantial commercial potential in use of the gas centrifuge to provide fuel for nuclear reactors.

How Can Classified Data Be Obtained?

The AEC proposes to establish a new category of information -- Isotope Separation - Gas Centrifuge Method -- to its long-standing access permit program. This program permits individuals, after appropriate security clearance, to obtain access to restricted data for private business and research uses. To participate you must meet AEC requirements for protecting classified information.

To participate, firms would be required to:

✓ Demonstrate a capability for, and serious interest in, making a substantial effort to engage in gas centrifuge development.
✓ Report to the AEC the results of their work in the gas centrifuge field during the period covered by the access permit and for one year thereafter.
✓ Make available to AEC for inspection all technical data developed in the course of their work in the gas centrifuge field during the period of the permit and for one year thereafter.
✓ Grant to the Government upon request a non-exclusive, irrevocable, reasonable royalty-bearing license to use for government purposes any patent on any invention or discovery made or conceived in this field during the term of the permit and for one year thereafter.
✓ Grant to the AEC the right to use, for AEC programs, any of the permittee's proprietary data developed in the course of their work in the gas centrifuge field which were developed during the term of the permit and for one year thereafter, subject to the payment of reasonable compensation by AEC for any use of such data that AEC may desire to make.

In addition, any permittee desiring to build or operate a gas centrifuge plant would have to obtain the required licenses under Commission rules and regulations. However, granting of an access permit will impose no obligation on AEC to grant any license for a production facility or otherwise facilitate the commercial use or sale of any invention or development which may result therefrom.

(The Commission is placing copies of the "Notice of Proposed Rule Making" in its Public Document Room, 1717 H Street, N. W., Washington, D. C. All persons who desire to submit written comments and suggestions for consideration in connection with the proposed amendments to AEC access permit regulations should send them in triplicate to the Secretary, U. S. Atomic Energy Commission, Washington 25, D. C., Attention: Director, Division of Reactor Development, within 60 days after publication of the notice in the Federal Register on December 13, 1960.)

OFFICIAL ATOMIC ENERGY COMMISSION REPORT
ON STATUS OF GAS CENTRIFUGE TECHNOLOGY

(The following report on the status of technology on the gas centrifuge method for the separation of isotopes discusses the principle of the gas centrifuge, the possible advantages of this process and its possible use in the production of weapons material. The report also outlines the development work done by the United States and other countries and lists some of the problems which still must be solved.)

* PRINCIPLE OF THE GAS CENTRIFUGE

The theory of the gas centrifuge process is to pass uranium in gaseous form (uranium hexafluoride) through a centrifuge which spins at very high speeds. There is a slight difference in the weight of the uranium-238 and uranium-235 isotopes. Consequently, it is theoretically possible to separate these isotopes just as one can separate cream from milk by centrifugation. It must be emphasized, however, that although the same principle is involved, the gas centrifuge is a good deal more complex than the "cream separator" or other types of industrial centrifuges.

Only the uranium-235 portion of natural uranium (U-238) is fissionable and can be used for weapons purposes. Uranium-235 constitutes only .7 of a percentage point of natural uranium. The other 99.3 percent of uranium-238 is of no use for weapons. Therefore, it is necessary to separate the uranium-235 from uranium-238.

* POSSIBLE ADVANTAGES

Two possible advantages of the gas centrifuge method, as compared with the gaseous diffusion process we now use for uranium isotope separation, are the potential lower requirement of a centrifuge plant for electric power and its potential requirement for fewer units in series in order to produce the desired enrichment of uranium-235. Further it appears to be particularly well suited for low-capacity installations.

The centrifuge process has the interesting theoretical property that the separative work performed varies with the fourth power of the speed, all other factors being equal. This means that doubling the speed would, in theory, increase the separative work performed by the unit by a factor of sixteen. With this potential, as progress is made in materials of construction and equipment design, enthusiasm rises for the application of this process to the separation of uranium isotopes. In at least one respect this is a desirable situation since promising processes should be developed for uranium-235 separation as a step toward possible improvement in the economics of nuclear power.

* USE FOR WEAPONS MATERIAL

A review by the Commission of available information on the gas centrifuge machines built both here and abroad indicates that these machines cannot now be used in a production plant without further development work. So far, centrifuge units have been operated only as single laboratory models for isotope separation. These machines are complex and expensive.

Even after substantial improvements have been made, thousands of gas centrifuges probably would be required to produce enough enriched uranium for one crude weapon per year. Including auxiliaries, a plant of this type might cost several thousand dollars per centrifuge. Compared with development by the United States, the time period would be much longer for a country not presently engaged in centrifuge research and development and not having access to advanced technical and industrial capability.

* DEVELOPMENT PROBLEMS

General areas in which problems still must be solved before a satisfactory process is possible with the current centrifuges include:

✓ Reliability of the present experimental machines for continuous, long-term service with uranium hexafluoride must be proved out.

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* DEVELOPMENT PROBLEMS -- (continued)

✓ A model of the machine satisfactory for mass production of identical units must be developed.

✓ A method must be developed to provide for the introduction and removal of gas when the machines are grouped as would be necessary in a production plant.

✓ The auxiliary processes, services and instrumentation necessary for plant operations have to be determined.

None of these problems is simple to solve. Excellent technical and industrial talent are required.

* DEVELOPMENT WORK BY UNITED STATES

The United States has followed development of this process for some time. The gas centrifuge was one of the methods investigated during World War II. Development work on the centrifuge method had not progressed so far as other methods when it became necessary to select the processes to be used in production plants. The United States temporarily discontinued work on the centrifuge and went ahead with gaseous diffusion, thermal diffusion and the electromagnetic methods for production or uranium-235.

Although the United States ultimately continued to employ the gaseous diffusion method as the most economical process available, the Commission has not lost sight of the gas centrifuge's possibilities. The AEC resumed research on the centrifuge method in 1953 and expanded this work gradually as the technology advanced. Most of the Commission's research work has been carried out at the University of Virginia.

As the technology advances, it will be possible to make more realistic appraisals of the economic attractiveness of this method for the separation of uranium-235. The Commission has recently increased the United States effort on the development of the centrifuge program. It is now expected that the total effort will be at a level of roughly $2 to $3 millions per year. Because of its potential significance to production of weapons materials, however, the program is classified.

The technology of centrifuge separation is not now developed to a point where this process can produce uranium-235 at a cost competitive with the product from AEC's current gaseous diffusion plants. On the other hand, projections of possible gains in the gas centrifuge process indicate the possibility that the process may become attractive from the economic standpoint in the future. However, this would require very substantial further advances in the technology. In this country, the gaseous diffusion method remains the most economical process for large-scale production of uranium-235 at this time.

Since there has been considerable commercial interest expressed in possible industrial application of the gas centrifuge process to the development of economic nuclear power, the Commission has approved a program under which private industry in the United States will be permitted to work on the centrifuge process with private funds, under appropriate conditions and security.

* WORK IN OTHER COUNTRIES

Scientists in West Germany and the Netherlands also have worked to develop the potential of the gas centrifuge process for its interesting scientific and commercial possibilities. They have been particularly interested in the potential of the centrifuge for the production of low enriched uranium for civilian research and power reactors.

In July of 1960 representatives of the Department of State and of the Atomic Energy Commission discussed centrifuge technology with the West German and Netherlands Governments and the United States asked that Germany and the Netherlands give consideration to the control of gas centrifuge technology. The two countries shared the concern of the United States over the possible application of the centrifuge process for weapons production.

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* WORK IN OTHER COUNTRIES -- (continued)

The West German Government recently announced that it has taken steps to control the dissemination of information on the gas centrifuge process. The United States understands that the Netherlands Government is actively studying the question of applying controls to its work.

The United States also discussed the gas centrifuge question with the United Kingdom. The United Kingdom follows classification criteria similar to those of the United States on the gas centrifuge process.

* OTHER METHODS FOR PRODUCING FISSIONABLE MATERIAL

There are already two methods -- available today -- to produce weapons material. These proven methods are (1) the gaseous diffusion method of producing enriched uranium and (2) the use of reactors, which produce plutonium.

Three nuclear powers, the United States, the United Kingdom and the Soviet Union, have built gaseous diffusion plants to produce uranium-235 for weapons purposes. In each case this has been a very costly undertaking and in each case the technology has been held secret. Gaseous diffusion plants are inherently of substantial capacity and require very large amounts of electrical power. For various reasons, it is unattractive for many countries to proceed with the necessary effort to build even a small gaseous diffusion plant.

France, for example, while planning to build a gaseous diffusion plant, achieved its first nuclear device from plutonium produced in reactors fueled with natural uranium.

Technology applicable to the production of plutonium in reactors has been widely disseminated in the course of the program for the development of the peaceful uses of the atom, and this technology could be used to assist any country in attaining a weapons capability.

For example, it is possible for a country to develop a plutonium production capability to produce one crude weapon per year with an investment on the order of $50 million.

The application of plutonium technology, the additional development work and the construction of a small plutonium production complex would not be a simple task. In order to accomplish this within a period of four to five years, a country must have a substantial technical and industrial capability of its own, or it must receive assistance from a country that has such a capability.

* CONTROL PROBLEM

The United States has supported broad international safefuards to insure that plutonium, as well as any other nuclear material used or produced in peaceful programs, are not diverted to weapons uses.

The General Conference of the International Atomic Energy Agency, which met in Vienna in September, endorsed proposed safeguards to apply to reactors and special nuclear materials that will be subjected to IAEA controls. The principle of these safeguards can be extended to apply to the gas centrifuge.

The United States also has sought agreement among supplier nations of natural uranium to control international traffic in this material to assure that it will be used only for peaceful purposes. In over forty bilateral agreements for cooperation in civil uses of atomic energy, the United States has obtained guarantees from its cooperating partners that any materials or equipment received or produced as a result of such cooperation will not be used for military purposes. The United States has been given rights of inspection in order to assure that these guarantees are met.

PUBLICATION CHECKLIST

- ☐ HEAT CAPACITIES OF CRYOGENIC MATERIALS, a publication expected to be of value to designers of cryogenic equipment by compiling heat capacity data on cryogenic materials. Tables are given of the specific heat and the enthalpy of 28 metals, 3 alloys and 8 other inorganic substances, and 8 organic substances in the temperature range 1 to 300° K. 20 Pages. 20 cents. (Write Superintendent of Documents, Government Printing Office, Washington 25, D. C. for NBS Monograph 21.)

- ☐ SCIENCE DOCTORATES, a Government study indicating that universities and colleges employ most of the nation's new science doctorate holders -- and that the number of such doctorates reached 5,300 last year, an all-time high. 28 Pages. 25 cents. (Write Superintendent of Documents, Government Printing Office, Washington 25, D. C. for Publication NSF 60-60.)

- ☐ SCIENTIFIC DOCUMENTATION, the latest in a series of reports compiled by the National Science Foundation on research and development in the U. S. and overseas concerned with the problems of information storage and retrieval. 153 Pages. 65 cents. (Write Superintendent of Documents, Government Printing Office, Washington 25, D. C. for Publication NSF 60-65.)

- ☐ CENSUS OF MINERAL INDUSTRIES, a series of final industry reports covering the year 1958, to be issued through early 1961. Provides general statistics by states and types of operation; selected general statistics by size of establishment; detailed data for selected areas and information on supplies and energy used. (Write Publications Office, U. S. Department of Commerce, Washington 25, D. C. for Census Bureau Announcement and Order Form 19-92.)

- ☐ CLIMATOLOGY AT WORK, a detailed description of the functions, scope and capabilities of the centralized U. S. climatological facility located at Asheville, North Carolina. Includes much information on the science of climatology and technical details of observations, methods, the use of computers and the form and availability of climatological information. A useful publication for anyone interested in this field. 109 Pages. 65 cents. (Write Superintendent of Documents, Government Printing Office, Washington 25, D. C. for "Climatology at Work.")

- ☐ FEDERAL ASSISTANCE TO U. S. SHIPPING, a new booklet explaining the various types of Government aid available to the American Merchant Marine, including subsidies, loans and tax benefits. 12 Pages. 15 cents. (Write Superintendent of Documents, Government Printing Office, Washington 25, D. C. for "The American Merchant Marine and Federal Assistance Programs.")

- ☐ DUST EXPLOSION TESTING, a technical report on standard laboratory tests of dust explosibility, describing U. S. Bureau of Mines procedures. Single Copies Free. (Write Publications-Distribution Section, U. S. Bureau of Mines, 4800 Forbes Avenue, Pittsburgh 13, Pennsylvania for Report of Investigations No. 5624, "Laboratory Equipment and Test Procedures for Evaluating Explosibility of Dusts.")

- ☐ KINETICS OF GASES, the results of a group effort at Northwestern University to survey the current status of knowledge concerning the kinetics of gases. The fundamental features of real gas effects are reviewed, with emphasis on high-temperature effects. 153 Pages. (Available through military channels or at $3 from OTS, U. S. Department of Commerce, Washington 25, D. C. Ask for AEDC-TN-60-130.)

- ☐ SPACE & NUCLEAR ENERGY, a progress report on the development of nuclear systems for space propulsion by Harold B. Finger, Manager, AEC-NASA Nuclear Propulsion Office. 15 Pages. Single Copies Free. (Write Information Office, NASA, 1520 H Street, N. W., Washington 25, D. C. for Release 60-306.)